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SEASONAL ABUNDANCE OF EGGS OF THE CORN EAR WORM MOTH IN VIRGINIA

By W. J. Phillips and G. W. Barber

Cereal and Forage Insect Investigations

Bureau of Entomology and Plant Quarantine

INTRODUCTION

The determination of the seasonal abundance of the different stages of the corn ear worm (*Heliothis obsoleta* (F.)) is attended by so many difficulties that, in studying the seasonal history of the insect, investigators have usually restricted themselves to insectary rearings of isolated individuals under artificial conditions. A more complete knowledge of the seasonal history and abundance of the insect as it is found in nature was needed.

The fact that this insect passes part of its life in the soil makes field counts of pupation and emergence impracticable. The moths are rapid fliers and move about so freely that it is difficult to make accurate observations of their habits. Observations on the infestation of corn ears in the field may give information relative to seasonal abundance and life history, but it is by no means certain with what degree of accuracy the numbers of larvæ occurring at any time may be determined. On the other hand, observations to determine the abundance of eggs can be made much more easily and with much greater accuracy. The seasonal variations in egg abundance should indicate the prevailing moth population with a fair degree of exactness and should also indicate what the subsequent larval population will be. The occur-

rence of eggs, therefore, should give the most accurate information obtainable of seasonal history and abundance of the insect.

One of the difficulties encountered in the determination of the seasonal history and abundance of the insect by observation of oviposition lies in the fact that corn is more attractive to the moths for egg laying at certain stages of its growth than at others. It is most attractive while the plants are in the fresh-silk stage, and least attractive while the plants are small or after they have ripened. In the latitude of Virginia corn may be planted during a period of more than 2 months. An early-maturing variety planted the first of April may begin to silk by mid-June, whereas corn planted in June may not begin to silk until September. Since plants with fresh silks are more attractive than others for oviposition, the concentration of eggs on plants during June, for instance, would be far greater on the early-planted than on later-planted corn. Therefore, the examination of a single planting of corn would not show the actual abundance of moths throughout the season, for, though eggs might be laid late in the season in great numbers, they would be deposited on plants in fields that were in more attractive stages of growth.

To determine the seasonal occurrence and abundance of eggs, numerous plantings of corn were made throughout the growing season at Charlottesville, Va., each year from 1921 to 1927, excepting 1923. Similar plantings were made at Richmond, Va., from 1924 to 1927. Such plantings, except during the early part of a season, provided plants continuously in the stages of growth favorable for oviposition. Fresh silks often appeared by the second or third week of July and were continuously present thereafter until the first week in October.

A number of representative plants were chosen from each plot, and, except when weather prevented, daily records were made of the number of eggs deposited on each plant. All eggs were removed each day except those on certain plants set apart for determination of the fate of the eggs. These eggs were marked and their positions noted, so that new depositions could be easily recognized. Observations of a given plant were discontinued 3 days after the silks had completely dried, or somewhat before roasting-ear stage. From these records it was possible to deter-

mine the average deposition of eggs per plant per day and to chart the seasonal occurrence and abundance of eggs. The advantage of this method of recording the eggs deposited on a number of plants in various stages of growth was that field conditions as found in the section in which these studies were made were approximately simulated except, of course, for seasonal variation in acreage. No definite planting date for corn is usually observed by farmers, and for this reason plants in various stages of growth are present in the field over a period of several months.

In the manner described, 16 studies were made of the local seasonal occurrence of the eggs of the corn ear worm in the localities and years mentioned. In all, complete oviposition records on 891 corn plants, representing 267 plots, were obtained. A total of 43,828 eggs were recorded, or an average of 49 eggs per plant. A total of 52,818 plant observations were made. The average rate of oviposition per plant per day was 0.83 for all years and localities.

Periods of occurrence of the corn ear worm in Virginia

In the latitude of Virginia several generations of the insect occur annually. Moths appear first between the last of May and the middle of June, and they continue to emerge from hibernation throughout June and July. Emergence is somewhat irregular because of the operation of several natural factors, such as precipitation and soil temperature. Since a generation may be completed in about 5 weeks, an overlapping of broods occurs from July onward through the season. For convenience in this study, and because generations cannot be recognized, the season was divided into two periods. The first period comprised roughly May, June, and July, and the second period consisted of August, September, and October.

Corn plots used in these studies

At Charlottesville, Va., three series of plots were used. These were designated as upland, bottom, and garden plots. The upland plots were located in a field of clay loam which sloped toward the west. Each plot consisted of three rows of field corn across the field. The bottom plots, also of field corn, were located in a river-bottom field about one-half mile south of the upland plots.

The garden plots each consisted of two rows of sweet corn in a vegetable garden in rich loam about 600 yards south of the upland plots. The plots at Richmond, Va., on level upland in sandy loam soil, consisted of field corn, and were similar in size to the upland plots at Charlottesville.

The upland and bottom plots at Charlottesville were planted to the same varieties of field corn and on similar dates. Common varieties of sweet corn were used in the garden plots, plantings being started earlier and being made at greater intervals than in the other plantings. The plantings in four localities, in different soil types, and at dates spread throughout the season, covered as wide a range of environment as it was possible to observe.

SEASONAL OCCURRENCE OF EGGS

The studies were begun each year when the earliest corn plants were about 8 inches tall, and continued until all corn had lost its attractiveness to the moths and egg laying on it had ceased.

The date when eggs were first found on corn in any year depended on two factors, (1) when moths emerged from hibernating pupæ, which was dependent on spring weather, and (2) the time when corn was planted and the rate at which it grew, also dependent on spring weather, making for earliness or lateness of the season. The date on which the first eggs were laid on corn varied about a month in different years. The earliest occurring eggs were found on May 21, 1925, at Richmond. The lateness of occurrence of corn in attractive stages of growth in the fall, and consequent occurrence of ear worm eggs on it, varied for similar reasons. The latest egg recovered on corn was on October 10 in Charlottesville upland plots in 1927. A record of egg recovery is given in table 1. A general summary of the results of this study is given in table 2.

Eggs were deposited on many days in each period. For each period, however, the proportion of days on which eggs were deposited, based on the total number of days of observation applicable to that period, was variable. Figure 1 shows the percentage of days in each period on which eggs were deposited. Within the first period the range was from 16.67 (bottom plots at Charlottesville in 1925) to 100 per cent (upland plots at Charlottesville in

TABLE 1.—*Average occurrence of corn ear worm eggs on corn plants during each 5-day period during the season (number of eggs per plant per day)*

Locality	Year	Environment	MAY		JUNE						JULY					
			21–25	26–31	1–5	6–10	11–15	16–20	21–25	26–30	1–5	6–10	11–15	16–20	21–25	26–31
CHARLOTTESVILLE	1921	upland	—	0.21	0.10	0.13	0.13	0.13	0.56	0.66	1.04	1.46	0.68	0.47	0.11	0.06
	1922	upland	—	.08	.03	.18	.09	.11	.16	.07	.02	.09	.09	.14	.31	.25
	1922	bottom	—	—	.05	.13	.07	.05	.08	.12	.06	.07	.03	.09	.12	.10
	1924	upland	—	—	—	—	—	.08	.25	.28	.41	.22	.06	.09	.09	.04
	1924	bottom	—	—	—	—	—	—	—	.06	.26	.09	.02	.00	.03	.03
	1925	upland	—	—	—	—	—	—	—	.05	.00	.03	.03	.00	.02	.00
	1925	bottom	—	—	—	—	—	—	—	.00	.00	.02	.01	.00	.00	.03
	1925	garden	—	—	—	—	.07	.11	1.24	.54	.95	.21	.05	.05	.09	.02
	1926	upland	—	—	—	—	—	.21	.22	.14	.11	.09	.04	.04	.08	.19
	1926	garden	—	—	—	—	.52	3.97	4.18	2.74	1.18	1.22	1.02	.82	.11	.13
	1927	upland	—	—	.00	.08	.13	.11	.26	.14	.09	.04	.22	.37	.78	.35
	1927	garden	—	.00	.14	.51	.47	.64	3.87	.63	.75	2.82	4.07	3.83	3.57	1.07
	AVERAGE		—	.10	.06	.21	.21	.60	1.20	.45	.41	.53	.53	.49	.44	.19
RICHMOND	1924	upland	—	—	—	—	.06	.06	.19	.15	.07	.02	.01	.01	.01	.04
	1925	upland	.40	.09	.54	.47	.68	.31	.14	.04	.08	.16	.72	1.05	1.25	.74
	1926	upland	—	.28	.21	.15	.57	.40	.22	.12	.21	.53	2.33	.95	.45	.23
	1927	upland	—	2.70	1.05	.93	.57	.81	1.65	1.78	.96	.85	.84	1.37	.67	.12
	AVERAGE		.40	1.02	.60	.52	.47	.40	.55	.52	.33	.39	.98	.85	.59	.28

TABLE 1.—(*Continued*)

Locality	Year	Environment	AUGUST						SEPTEMBER						OCTOBER	
			1–5	6–10	11–15	16–20	21–25	26–31	1–5	6–10	11–15	16–20	21–25	26–30	1–5	6–10
CHARLOTTESVILLE	1921	upland	0.05	0.09	0.26	0.52	1.06	1.98	2.54	6.16	5.33	6.53	—	—	—	—
	1922	upland	.16	.08	.13	.55	1.60	2.75	4.25	4.27	1.18	—	—	—	—	—
	1922	bottom	.03	.01	.17	.16	.29	1.39	2.67	4.48	2.42	1.15	—	—	—	—
	1924	upland	.17	.31	.11	.24	.23	.42	.36	.10	.12	—	—	—	—	—
	1924	bottom	.08	.16	.23	.18	.29	.04	.40	.39	.07	.24	.00	—	—	—
	1925	upland	.03	.03	.09	.14	.09	.50	.52	1.08	1.85	2.74	2.33	2.29	—	—
	1925	bottom	.03	.02	.16	.16	.18	.29	.42	2.08	7.03	5.86	5.50	2.07	1.00	0.75
	1925	garden	.02	.07	.00	.03	.00	.07	.53	4.67	6.04	8.31	9.10	2.67	.95	.67
	1926	upland	.12	.05	.03	.32	1.23	1.30	1.63	2.89	2.98	1.59	4.53	5.92	—	—
	1926	garden	.03	.07	.00	.96	.69	.87	3.44	5.13	5.00	5.06	6.29	5.50	—	—
	1927	upland	.09	.08	.03	.01	.06	.06	.04	.12	.34	1.57	1.51	2.27	1.00	.07
	1927	garden	.12	.02	.00	.00	.02	.14	.37	.40	4.64	5.96	1.35	1.12	.68	—
	AVERAGE		.08	.08	.10	.27	.48	.82	1.43	2.65	3.08	3.90	3.83	3.12	.91	.50
RICHMOND	1924	upland	.21	.06	.06	.00	.02	.02	.07	—	—	—	—	—	—	—
	1925	upland	.86	.77	1.04	1.90	4.08	11.22	28.07	30.96	31.94	14.82	10.00	—	—	—
	1926	upland	.05	.15	.28	.83	1.40	3.15	3.10	2.75	2.08	2.14	—	—	—	—
	1927	upland	.12	.05	.08	.15	.10	.07	.16	.23	.07	.18	.87	.00	.00	—
	AVERAGE		.31	.26	.37	.72	1.40	3.62	7.85	11.31	11.36	5.71	5.43	—	—	—

TABLE 2.—*Summary of seasonal occurrence of eggs of the corn ear worm in Virginia*

Location	Year	Environment	Number of plots	Number of planting dates	Number of days observed	Number of days on which eggs were found	Total number of plants under observation	Seasonal dates					First period			Second period			Ratio of abundance of eggs of the second to those of the first period
								First examination	First recovery of eggs	First appearance of silk	First deposition of eggs of a second period	Last examination	Total number of days of observation	Average number of eggs per plant per day	Maximum number of eggs per plant on any one day	Total number of days of observation	Average number of eggs per plant per day	Maximum number of eggs per plant on any one day	
CHARLOTTESVILLE	1921	upland	44	9	113	111	133	May 30	May 30	June 19	Aug. 1	Sept. 19	63	0.51	2.66	50	1.04	13.25	2.04
	1922	upland	21	10	111	101	42	May 29	May 29	July 13	Aug. 7	Sept. 16	70	.14	1.30	41	1.25	5.11	8.93
	1922	bottom	17	8	110	83	34	June 2	June 2	July 11	Aug. 7	Sept. 19	66	.08	.33	44	.93	6.14	11.62
	1924	upland	14	7	92	75	42	June 17	June 18	July 23	Aug. 1	Sept. 16	45	.15	.66	47	.25	1.50	1.67
	1924	bottom	10	5	90	53	30	June 27	June 30	July 29	Aug. 1	Sept. 24	35	.06	.41	55	.19	1.50	3.17
	1925	upland	18	9	97	63	54	June 25	June 27	Aug. 1	Aug. 6	Sept. 29	42	.02	.12	55	.45	9.00	22.50
	1925	bottom	18	9	104	63	54	June 25	June 13	July 28	Aug. 6	Oct. 9	42	.01	.19	62	.92	14.75	92.00
	1925	garden	8	8	118	65	24	June 12	June 15	June 24	Aug. 6	Oct. 9	55	.31	1.91	63	2.73	23.00	8.81
	1926	upland	18	9	95	92	90	June 16	June 18	July 22	Aug. 7	Sept. 29	46	.12	.52	49	1.36	10.60	11.33
	1926	garden	7	7	102	77	21	June 9	June 9	June 18	Aug. 7	Sept. 28	52	1.19	5.77	50	2.09	15.00	1.76
	1927	upland	18	9	122	90	54	June 4	June 7	July 21	Aug. 7	Oct. 10	57	.25	1.50	65	.25	5.88	1.00
	1927	garden	9	9	115	75	27	May 25	June 3	June 23	Aug. 7	Oct. 5	63	2.04	8.53	52	.78	15.66	.38
RICHMOND	1924	upland	5	5	88	51	30	June 10	June 13	July 28	July 28	Sept. 5	42	.07	.33	46	.06	.56	.86
	1925	upland	19	9	127	125	95	May 21	May 21	June 12	Aug. 5	Sept. 24	76	.55	1.36	51	7.89	46.35	14.35
	1926	upland	18	9	111	110	90	May 27	May 27	July 11	Aug. 4	Sept. 20	67	.54	2.57	44	1.35	4.09	2.50
	1927	upland	23	11	120	104	71	May 27	May 27	June 24	Aug. 7	Oct. 2	66	.83	4.80	54	.11	1.20	.13

1921 and at Richmond in 1927). In the second period the range was from 53.85 per cent to three records of 100 per cent.

These studies showed that, because of the widespread occurrence of the eggs throughout each season, corn plants would probably receive eggs regardless of planting date.

SEASONAL ABUNDANCE OF EGGS

The abundance of eggs in the first period was frequently somewhat irregular, but in 10 of the studies the distribution was so uniform that no definite peaks of occurrence were found. In four of the seasonal histories, where eggs were less evenly distributed, more than one peak of occurrence was found, and a single definite peak of abundance was found only in two instances.

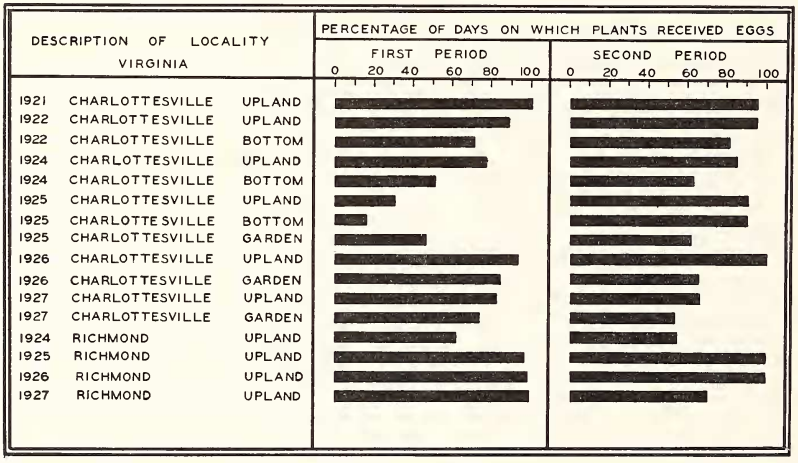

Figure 1. Percentage of days during the several studies of the seasonal history of the corn ear worm on which moths deposited eggs on corn plants. Based on the total number of days on which observations were made for the respective periods.

Numbers of eggs in the second period began to increase from the middle to the last of August, and reached clearly defined peaks of abundance from the middle to the last of September. During a period of about a month eggs usually were laid very plentifully. The egg laying during the second period was, therefore, usually concentrated within a relatively few days, in con-

trast to that of the first period, which was usually distributed over a larger number of days. The time of maximum abundance of eggs of the second period in 12 of the seasonal histories occurred either on a single date or extended over several days. However, in four instances the eggs were deposited more or less evenly during several weeks, and no well-marked peaks of abundance were found.

In all the seasonal occurrences studied, several days were found when the plants were relatively, sometimes entirely, free of eggs. The duration of the egg-free days, which usually occurred during the last week of July or the first week of August, ranged from a few days to 2 weeks or more.

In figure 2 the relative abundance of eggs of the first and second periods for each of the 16 seasonal histories studied is given. Eggs of the first period ranged in abundance from 0.01 egg per plant per day (bottom plots at Charlottesville in 1925) to 2.04 eggs per plant per day (garden plots at Charlottesville in 1927). In the second case eggs were 204 times as abundant as in the first. Eggs of the second period ranged in abundance from 0.06 egg per plant per day (upland plots at Richmond in 1924), to 7.89 eggs per plant per day (upland plots at Richmond in 1925). Second-period eggs at Richmond in 1925 were, therefore, 131.5 times as plentiful as in the same location in 1924.

Numbers of eggs during the two periods

A comparison of the numbers of eggs which occurred per plant per day in the two periods showed remarkable variation. This is illustrated graphically in figure 2. In each period, in the different seasonal histories, eggs ranged from scarce to abundant. Eggs of the second period were more abundant than those of the first period in 5 out of 6 years at Charlottesville, and in 2 out of 4 years at Richmond, and in 13 out of the 16 seasonal histories studied. In one seasonal history eggs of each period were equally abundant (Charlottesville upland plots of 1927). The numbers of eggs of the second period ranged from 0.13 to 92 times the number of eggs of the first period. These data are given in table 2.

The years 1924 and 1927 were apparently unfavorable for increase of this insect, while 1925 was the most favorable by far.

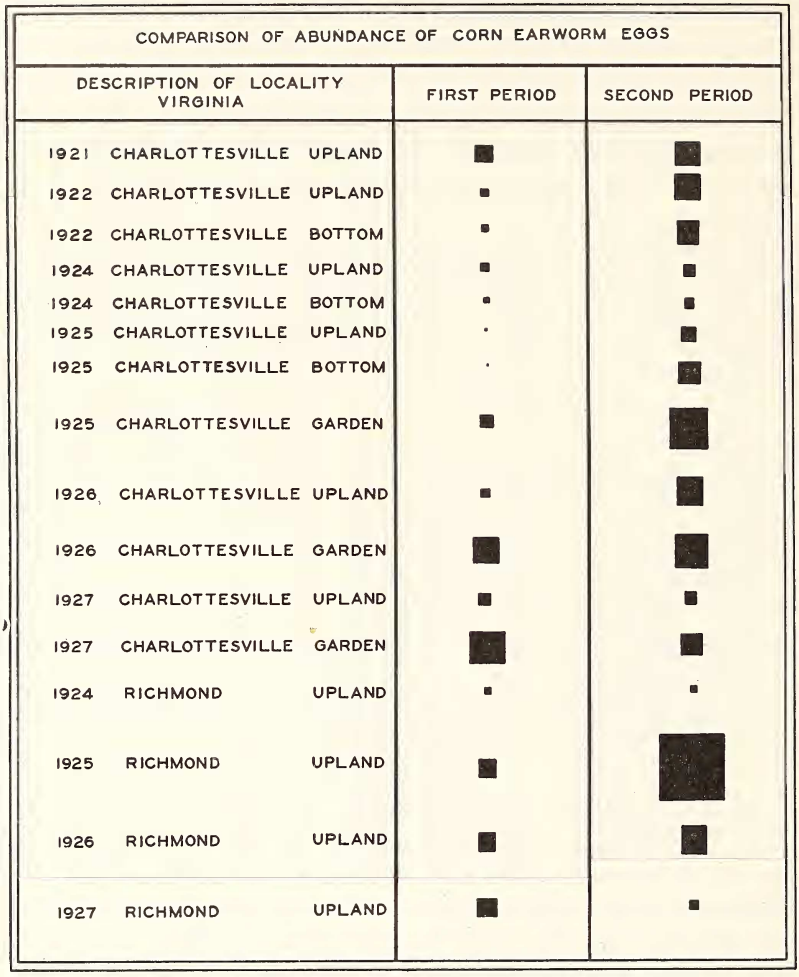

Figure 2. Comparison of abundance of eggs of the corn ear worm during two periods of the year for 16 seasonal-occurrence studies. The areas of the squares indicate the number of eggs deposited per plant per day.

RELATIONSHIP OF PRECIPITATION TO ABUNDANCE OF EGGS

While many factors influence the population of this insect, as determined by the number of eggs found on corn plants, none seems to be more important than precipitation during the oviposi-

tion period. Dry weather is definitely favorable in enabling the moths to lay their full complement of eggs, and in permitting a high rate of hatching and survival of young larvae. Since drought is usually accompanied by high temperatures, such conditions cause more rapid development of the various stages of the insect. During the course of these studies one year of severe drought occurred, 1925, especially during September. The insect, in response to favorable conditions, built up enormous populations in September. Eggs of the second period at Charlottesville were 15.17 times, and at Richmond 14.35 times, as plentiful as eggs of the first period.

The greatest rainfall occurring during any year of the study was at Richmond in 1927, and as an effect of this, eggs of the second period were 0.13 times as plentiful as eggs of the first period. The records of 4 years of study at Richmond showed that the proportion of eggs of the second to those of the first period varied directly with the precipitation during the months from June to September. For Charlottesville this relationship was less direct, probably because of the influence of other factors. These data are given in table 3.

SUMMARY

Because of the habits of the corn ear worm, it is not easy to determine the seasonal occurrence or abundance of the insect by means of counts of the pupæ, moths, or larvæ. It was thought that this information could be obtained by counts of eggs deposited on corn plants, as the numbers of eggs might reflect moth abundance and later larval populations indirectly.

Daily examination of selected corn plants of successive plantings in two localities and four environments, during 6 years, gave data on 16 seasonal records of egg occurrence.

Much difference was found in the seasonal occurrence of eggs. This depended in part on earliness or lateness of the spring or fall.

In each seasonal occurrence studied there were a number of days in the last week of July or the first week of August when eggs were extremely scarce or wholly wanting. This time of egg scarcity was used to divide each season into two periods, the first

TABLE 3.—*Precipitation during the oviposition period and the numbers of eggs deposited on corn plants by corn ear worm moths*

Locality	Year	Precipitation during oviposition period					Number of eggs per plant per day[1]			Ratio of abundance of eggs of the second to those of the first period
		June	July	August	September	Total	First period	Second period	Yearly average	
CHARLOTTESVILLE	1921	3.49	3.60	1.65	1.65	10.39	0.51	1.04	0.66	2.04
	1922	4.73	3.94	4.87	1.00	14.54	.12	1.12	.32	9.33
	1924	6.83	2.71	4.87	6.43	20.84	.11	.22	.17	2.00
	1925	2.19	2.26	2.73	.89	8.07	.06	.91	.53	15.17
	1926	1.47	3.30	8.23	2.59	15.59	.35	1.48	.85	4.23
	1927	1.65	5.33	3.72	3.47	14.17	.79	.37	.62	.47
RICHMOND	1924	4.85	2.33	3.05	9.58	19.81	.07	.06	.06	.86
	1925	2.24	2.32	2.55	.93	8.04	.55	7.89	2.89	14.35
	1926	2.19	7.17	5.24	1.46	16.06	.54	1.35	.78	2.50
	1927	3.12	9.10	7.19	4.01	23.42	.83	.11	.62	.13

[1] Number of eggs observed divided by number of plant-days (number of plants observed times number of days of observation).

comprising roughly May, June, July and the second consisting of August, September and October.

Abundance of eggs varied greatly in different years. Eggs of the first period ranged from 0.01 to 2.04 per plant per day. Eggs of the second period ranged from 0.06 to 7.89 per plant per day. When most plentiful, eggs of the first period were 204 times as numerous as in the year of least abundance, and eggs of the second period were 131.5 times as numerous as when least plentiful.

While eggs of the second period were usually more plentiful than those of the first period, in 3 of 16 instances they were less abundant, and in one case the numbers were equal. Numbers of eggs of the second period ranged from 0.13 to 92 times those of the first period.

Precipitation seemed to be a principal factor in determining the abundance of the eggs. During seasons of much rain the ear worm population increased little. During seasons of little rain populations increased greatly.